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Differential eyelid conditioning as a function of the probability of reinforcement.

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Differential Eyelid Conditioning as a Function of the Probability of Reinforcement

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Table of Contents

Page

Acknowledgements iii

Table of Contents iv

List of Tables v

List of Figures vi

List of Appendices vii

Introduction 1

Acquisition 3

Extinction 6

Method 9

Apparatus 9

Design 10

Procedure 10

Subjects 10

Definition of Response 11

Results and Discussion 12

Acquisition 12

Extinction 22

Concluding Remarks: Theory 32

References 35

Appendices 38

List of Tables

Table		Page
1	Experimental Design	2
2	Per Cent CRs to CS_1, CS_2, Difference Scores, and Average Per Cent CRs at Asymptote (Trials 49-112) for Each Group	14
3	*F* Values Testing the Significance of Differentiation (Groups x $CS_1 \div$ *S*s x CS_1/Groups, df = 1, 32) Where Each of the Ten Experimental Groups Was Contrasted with the Control Group 50/50 . .	15
4	*F* Values of Trend Tests on Analyses Comparing Asymptotic Per Cent CR_1 Among Groups for Which Either π_1 or π_2 Was Constant	18
5	Per Cent CRs and Extinction Index Scores to CS_1, CS_2, Difference Scores, and Average for All Groups	23
6	*F* Values of Trend Tests for Analyses Contrasting the Extinction Index for CS_1 and CS_2 Among Groups	25
7	*F* Values for EIs When Each of the Ten Experimental Groups is Contrasted with the Control Group 50/50 (df = 1, 32).	30

List of Figures

Figure | Page

1 Per cent CRs to CS_1 and CS_2 for each group over seven blocks of 16 acquisition trials, the first extinction trial, and four blocks of 5 extinction trials 13

2 Per cent difference between CR_1 and CR_2 where a) π_1 is constant and π_2 varies between groups and b) π_2 is constant and π_1 varies . . . 16

3 The percentage CR_1 and CR_2 where π_1 is the parameter and π_2 varies. 21

4 The extinction index values for resistance to extinction to CS_1 and CS_2 where π_1 varies and $\pi_2 = 0, .25$ 28

5 The EI_1 and EI_2 values for Groups 100/0, 100/25, 100/50, and 100/75 29

6 The mean percentage of CRs to CS_1 (CR_1) and CS_2 (CR_2) as a function of π_1 where $\pi_2 = 0$ . . . 33

List of Appendices

Appendix		Page
A	Neutral Instructions	38
B	Acquisition: Resulting $\underline{F}$ Values and Degrees of Freedom of all Main and Crossed Effects, and the Error Mean Square (in parentheses) for Each Analysis of Variance Contrasting Each Experimental Group with the 50/50 Control Group	39
C	Acquisition: Resulting $\underline{F}$ Values and Degrees of Freedom of all Main and Crossed Effects, and the Error Mean Square (in parentheses) for Each Analysis of Variance Contrasting Those Groups for Which π_2 Values Were Equal	43
D	Acquisition: Resulting $\underline{F}$ Values and Degrees of Freedom of all Main and Crossed Effects, and the Error Mean Square (in parentheses) for Each Analysis of Variance Contrasting Those Groups for Which π_1 Values Were Equal	45
E	Acquisition: The Source of Variance Table for the Analysis of Variance Contrasting All Eleven Groups	47
F	Acquisition: The Sums of Squares for the Main Effects of Groups and the Interaction, Groups x (CS_1 vs. CS_2), along with Mean Square Values for the Between- and Within-<u>Ss</u> Error Terms for the Analyses of Variance upon which Trend Tests Were Performed	48
G	Acquisition: Contrasts of CR_1 vs. CR_2 Between Groups Testing <u>a priori</u> Predictions by Partitioning the Groups x CS_1 Sums of Squares from the Analysis of Variance Performed on All Eleven Groups	49
H	The Observed First-Order Conditional Probabilities, the Frequency (Denominator) Contributing to Each Conditional, and the Marginal Probabilities for Each Group	51

List of Appendicies (Continued)

Appendix		Page
I	Extinction: Resulting *F* Values and Degrees of Freedom of all Main and Crossed Effects, and Error Mean Square (in parentheses) for Each Analysis of Variance Performed on the EI Scores Contrasting Each Experimental Group with the 50/50 Control Group	55
J	Extinction: Resulting *F* Values and Degrees of Freedom of all Main and Crossed Effects, and Error Mean Square (in parentheses) for Each Analysis of Variance Performed on the EI Scores Contrasting Those Groups for which π_2 Values Were Equal	58
K	Extinction: Resulting *F* Values and Degrees of Freedom of all Main and Crossed Effects, and Error Mean Square (in parentheses) for Each Analysis of Variance Performed on the EI Scores Contrasting Those Groups for which π_1 Values Were Equal	59
L	Extinction: Resulting *F* Values and Degrees of Freedom of all Main and Crossed Effects, and the Mean Square of the Error Terms (in parentheses) for Each Analysis of Variance Performed on the EI Scores Contrasting All Eleven Groups	60
M	Extinction: The Sums of Squares for the Main Effects of Groups and the Interaction, Groups x (CS_1 vs. CS_2), along with Mean Square Values for the Between- and Within-*Ss* Error Terms for the Analyses of Variance upon which Trend Tests Were Performed	61

Introduction

The classical paradigm of differential eyelid conditioning typically involves two CSs, one CS always paired with the UCS and the other never paired with the UCS. The measure of differentiation consists of taking the difference in percentage CRs elicited by each CS. The asymptotic level of percentage CRs and the degree of differentiation has been shown to be a direct function of (a) UCS intensity (Spence & Tandler, 1963), (b) the proportion of reinforced to nonreinforced trials (Gynther, 1957), (c) CS intensity (Moore, 1964), (d) the proximity of CS+, CS-, and an intertrial stimulus (Moore & Newman, 1966), (e) similarity of CS+ and CS- (Gynther, 1957; Moore, 1964), and (f) the interval between the onset of the CS and the onset of the UCS (Hartman & Grant, 1962). The aim of the present study was to specify the role of the probability of reinforcement (π) in the establishment of differential eyelid conditioning by varying π independently for each CS.

The design employed a random sequence of presentations of two pure tones, CS_1 and CS_2, for an equal number of trials. CS_1 was reinforced on π_1 of the CS_1 trials and CS_2 was reinforced on π_2 of the CS_2 trials such that $\pi_1 > \pi_2$ for ten experimental groups. In addition, there was a control group for which $\pi_1 = \pi_2 = .50$. The design is summarized in Table 1 which shows (a) the percentage of reinforcement (π_i) for each of the two CSs, (b) the difference

Table 1

Experimental Design

Group	Percentage of Reinforcement			
	CS_1	CS_2	Difference	Average
100/0	π_1=1.00	π_2= 0	$(\pi_1-\pi_2)$=1.00	$(\pi_1+\pi_2)/2$=.50
75/0	.75	0	.75	.375
50/0	.50	0	.50	.25
25/0	.25	0	.25	.125
100/25	1.00	.25	.75	.625
100/50	1.00	.50	.50	.75
100/75	1.00	.75	.25	.875
75/25	.75	.25	.50	.50
75/50	.75	.50	.25	.625
50/25	.50	.25	.25	.375
50/50 (control)	.50	.50	0	.50

in percentage of reinforcement between CS_1 and CS_2 ($\pi_1 - \pi_2$), and (c) the probability of the UCS averaged over the two CSs [$(\pi_1 + \pi_2)/2$].

Acquisition.--This study focused on four models which predict what might occur when π_1 and π_2 are systematically varied. Two of the models under consideration were the Burke-Estes (1957) linear model and Estes' (1959) one-element pattern model. Both predict that (a) the percentage of CRs to each CS_i is a direct function of π_i (i.e., the probability that CS_i is reinforced, $i = 1, 2$), (b) difference scores are directly related to the difference between π_1 and π_2, and (c) the magnitude of differentiation will be equal where the differences between π_1 and π_2 are equal.

The Burke-Estes (1957) linear model describes the asymptotic probability of a CR as a joint function of the proportion of hypothetical stimulus elements common to both CS_1 and CS_2 and the probability with which each is reinforced, π_i, $i = 1, 2$. The probabilities of a CR given CS_1 and CS_2 are:

$$P_{11} = (1 - \underline{w})\pi_1 + \underline{w}\pi_a \qquad [1]$$

$$P_{12} = (1 - \underline{w})\pi_2 + \underline{w}\pi_a \qquad [2]$$

where $\pi_a = (\pi_1 + \pi_2)/2$, $\underline{w} = N(CS_1 \cap CS_2)/N(CS_1) = N(CS_1 \cap CS_2)/N(CS_2)$, and where $N(\cdot)$ refers to the number of stimulus elements in a set.

Estes' one-element pattern model treats each CS as a single pattern rather than a set of elements as assumed in the linear model. The basic assumption is that patterns are perceived as either identical or totally distinct. If we assume that the two CSs were clearly distinguishable by all Ss, then the one-element pattern model predicts that $P_{11} = \pi_1$ and $P_{12} = \pi_2$.

A third set of predictions was generated in terms of the contribution of the π_1 value to the distinctiveness between the CS_1 and CS_2 stimulus complexes. When either reinforcement or nonreinforcement was unique to one CS and not the other, then the fact of reinforcement (or nonreinforcement) may itself serve as an additional discriminable element of the CS complex. The assumption is that recognition responses associated with reinforcement or nonreinforcement develop stimulus properties which, through response mediation (Grice, 1965), become connected with the CS_1 and CS_2 stimulus complexes, respectively, thus providing the additional basis for differentiation. Thus, the situation which provided the greatest distinctiveness between the CSs would be where CS_1 was always paired with the airpuff UCS and CS_2 was never reinforced. Here, reinforcement was an additional feature of the CS_1 complex, while nonreinforcement was part of the CS_2 complex. Less distinctiveness between the CSs obtained where CS_1 was always reinforced and CS_2 was partially reinforced, and a comparable situation existed where CS_1 was partially reinforced and CS_2 was never reinforced. For the former situation, the fact that nonreinforcement always accompanies CS_2 was the distinguishing feature and for the latter situation, 100 per cent reinforcement was the additional feature of the CS_1 complex. Finally, the situation which provided the poorest distinctiveness between the CSs was where both CSs were partially reinforced. On the basis of this discussion, the following explicit prediction regarding difference scores was made for the ten experimental groups:

$$100/0 > (75/0 = 50/0 = 25/0 = 100/25 = 100/50 = 100/75) > (75/25 = 75/50 = 50/25). \quad [3]$$

If, as in the two quantitative models, it is assumed that differentiation also depends upon the difference between π_1 and π_2, as well as the reliability of reinforcement or nonreinforcement, then the set of ordinal predictions becomes highly similar to those of the two quantitative models:

$$100/0 > (100/25 = 75/0) > (100/50 = 50/0) > (100/75 = 25/0) > (75/25) > (75/50 = 50/25). \quad [4]$$

The major difference between the relationships in [4] and those derived solely from the quantitative models is the ordinal placement of groups 75/25, 75/50, and 50/25, i.e., those groups for which neither π_1 nor π_2 equals 1 or 0. Investigation of the relationships expressed in [3] and [4] represented an attempt to describe the effects of both the <u>reliability</u> of reinforcement or nonreinforcement and the <u>difference</u> in the probability of reinforcement as contributing facets of differentiation.

A final set of predictions were generated from the notion that an eyelid CR attenuates the noxious effect of a

UCS and that the Ss perform in a fashion which maximizes the probability of a CR on a reinforced trial (Prokasy, 1965; Martin & Levey, 1965). The optimal strategy would seem to be to respond on all trials for which a UCS might occur. Thus, when π_1 and π_2 are both greater than zero, no differentiation should result since the Ss respond maximally to both CSs.[1]

Extinction.--The present experimental design also offered a possible clarification of the partial reinforcement effect (PRE). The PRE is an empirical finding whose basic characteristics are fairly well-known in simple eyelid conditioning (Lewis, 1960; Ross & Hartman, 1965). In these studies extinction data typically show an inverted U-shaped function, i.e., resistance to extinction increases up to a high at 50 per cent reinforcement and then decreases to a low at 100 per cent reinforcement (Grant & Schipper, 1952; Lewis, 1960; Ross & Hartman, 1965). For the present design, all groups were under partial reinforcement with regard to the probability of the UCS averaged over all trials, i.e., $(\pi_1 + \pi_2)/2 < 1$.

According to a discrimination hypothesis (Spence, Rutledge, & Talbott, 1963; Spence, Homzie, & Rutledge, 1964), resistance to extinction should be related to the similarity of reinforcement schedules between acquisition and extinction.

---

[1] Maximal responding would not necessarily mean that $P(CR) = 1$ at asymptote, since 100 per cent conditioning has not been found in eyelid studies when group data is considered, although some individual Ss may have $P(CR) = 1$ at asymptote.

That is, a low value of π_1 in acquisition would be more similar to extinction where $\pi = 0$. Supposedly, the extinction process is facilitated when S "realizes" that reinforcement has ceased and S develops a corresponding inhibitory set. The discrimination hypothesis assumes that the number of extinction trials required to establish the inhibitory set would be inversely related to the percentage of reinforcement (Spence, Homzie, & Rutledge, 1964). In this simple form, the discrimination hypothesis predicts that resistance to extinction in the present design would be an inverse function of $(\pi_1 + \pi_2)/2$.

Unexpectedly, in light of earlier work (cf. Pavlik & Carlton, 1965), Amsel and Ward (1965) and Pavlik, Carlton, and Manto (1965) have found that the PRE where $\pi_1 = 1.00$ and $\pi_2 = .50$ can be obtained as a within-Ss effect with rats in both a double runway and a lever pressing situation. It was possible to test if the PRE also occurs as a within-Ss effect in classical differential eyelid conditioning by comparing resistance to extinction of CRs to CS_1 and CS_2 in groups for which $\pi_1 = 1.00$ and π_2 varied from .25 to .75. Given this effect, it was of interest to establish whether the within-Ss PRE was independent of overall level of drive (Spence, Homzie, & Rutledge, 1964) by comparing resistance to extinction to each CS taken separately only in groups for which the $(\pi_1 + \pi_2)/2$ values were equal (Spence, 1958). Spence and his associates assume that overall drive level for any defensive conditioning situation is a direct function of the number of UCS occurrences. From this viewpoint, therefore, it was possible to test for a within-Ss PRE by examining the three sets of groups for which overall drive levels $[(\pi_1 + \pi_2)/2]$ are equal within each set: (a) 100/25 = 75/50 = 62.5 per cent, (b) 100/0 = 75/25 = 50/50 = 50.0 per cent, and (c) 75/0 = 50/25 = 37.5 per cent.

Method

Apparatus.--The apparatus has been partially described elsewhere (Moore & Newman, 1966). The Ss' room contained two identical enclosures which permitted one or two Ss to be run during a session, each with identical stimulating and recording equipment. Auditory stimulation was generated by Hewlett-Packard audio-oscillators (Model 200-AB) and a Grason-Stadler noise generator (Model 455-C) and delivered over impedance-matched loud speakers in S's enclosure. The intensity of all tones presented to the S was 79 db SPL. The intensity of the continuous masking noise was 70 db SPL.

Each S wore a Waltke elastic headband supporting an airjet with a 1/16 in. orifice and a Minitorque potentiometer (Giannini Model 35153) which picked up movements of the right eyelid. Signals from the potentiometer were recorded by an Offner type-RP Dynograph during both the on-trial and intertrial periods. The speed of the paper was 100 mm/sec. for the on-trial interval and 1.67 mm/sec. for the intertrial interval.

The CSs were pure tones (600 and 1,000 cps) of 850 msec. duration, terminating on reinforced trials together with a 50 msec. airpuff so as to provide an 800 msec. CS-UCS interval. This CS-UCS interval is considered optimal for differential eyelid conditioning (Hartman & Grant, 1962). The UCS intensity was 100 mm. Hg static pressure (1.96 psi). The interval between trials was either 15, 20, or 25 sec. from UCS offset to CS onset, varied randomly.

Design.--The design discussed in the introduction was completed with 20 Ss per experimental group counterbalanced for S's sex, recording channel, and assignment of the two tones as CS_1 and CS_2. All female Ss were run in one recording channel and males in another, thus confounding sex and recording channel as one variable. An additional group of 20 Ss, receiving 50 per cent reinforcement for CS_1 and CS_2 ($\pi_1 = .50$ and $\pi_2 = .50$), served to demonstrate that the level of acquisition and resistance to extinction were essentially equal for CS_1 and CS_2 when under the same reinforcement schedule.

Procedure.--Following "neutral" instructions (cf. Appendix A), all Ss received 56 CS_1 trials and 56 CS_2 trials presented in random order for a total of 112 acquisition trials. The restrictions on the random order of CS presentations were that a CS occurred no more than twice in succession and that each CS occurred equally often for each block of 16 trials. This was immediately followed by 20 extinction trials, randomizing 10 trials to CS_1 and 10 to CS_2.

Subjects.--One hundred and ten males and 110 females were recruited from the introductory psychology classes at the University of Massachusetts.

Definition of Response.--Deflections greater than 1 mm. of the recording pen within a latency of 150-825 msec. following CS onset were considered to be CRs during both acquisition and extinction.

Results and Discussion

Acquisition.--The differential conditioning curves, presented in Fig. 1, show that all groups reached an asymptotic performance level by the third or fourth block of 16 trials. The percentage of CRs to CS_1 and CS_2, the difference scores ($CR_1 - CR_2$), and the average percentage of CRs $[(CR_1 + CR_2)/2]$ for the asymptotic trials (49-112) are shown in Table 2. Inspection of Fig. 1 and the difference scores in Table 2 suggests that differentiation was a direct function of the difference between π_1 and π_2 ($\delta\pi$) only in those instances where $\pi_2 = 0$ and $\pi_1 = .25$, .50, .75, and 1.00. No orderly function for difference scores appeared for the remaining seven groups. Table 3 shows the results of analyses of variance of the interaction of Groups x (CS_1 vs. CS_2) for each of the ten experimental groups compared with the 50/50 control group. The degree of differentiation for each of these groups was tested by dividing the mean square of Groups x CS_i, $i = 1, 2$, by the error mean square, Ss x CS_i/Groups. By the criterion of a $p < .05$ as a minimum level of significance, only the 100/0 and 75/0 groups differentiated the two CSs, $F(1, 32) = 22.558$, $p < .001$, and 13.146, $p < .01$, respectively. The F value for 50/0 vs. 50/50 was 4.09 which approaches but does not attain the .05 level.

Figure 2 shows the difference scores plotted separately with π_2 as the parameter (the left-hand panel) and with π_1

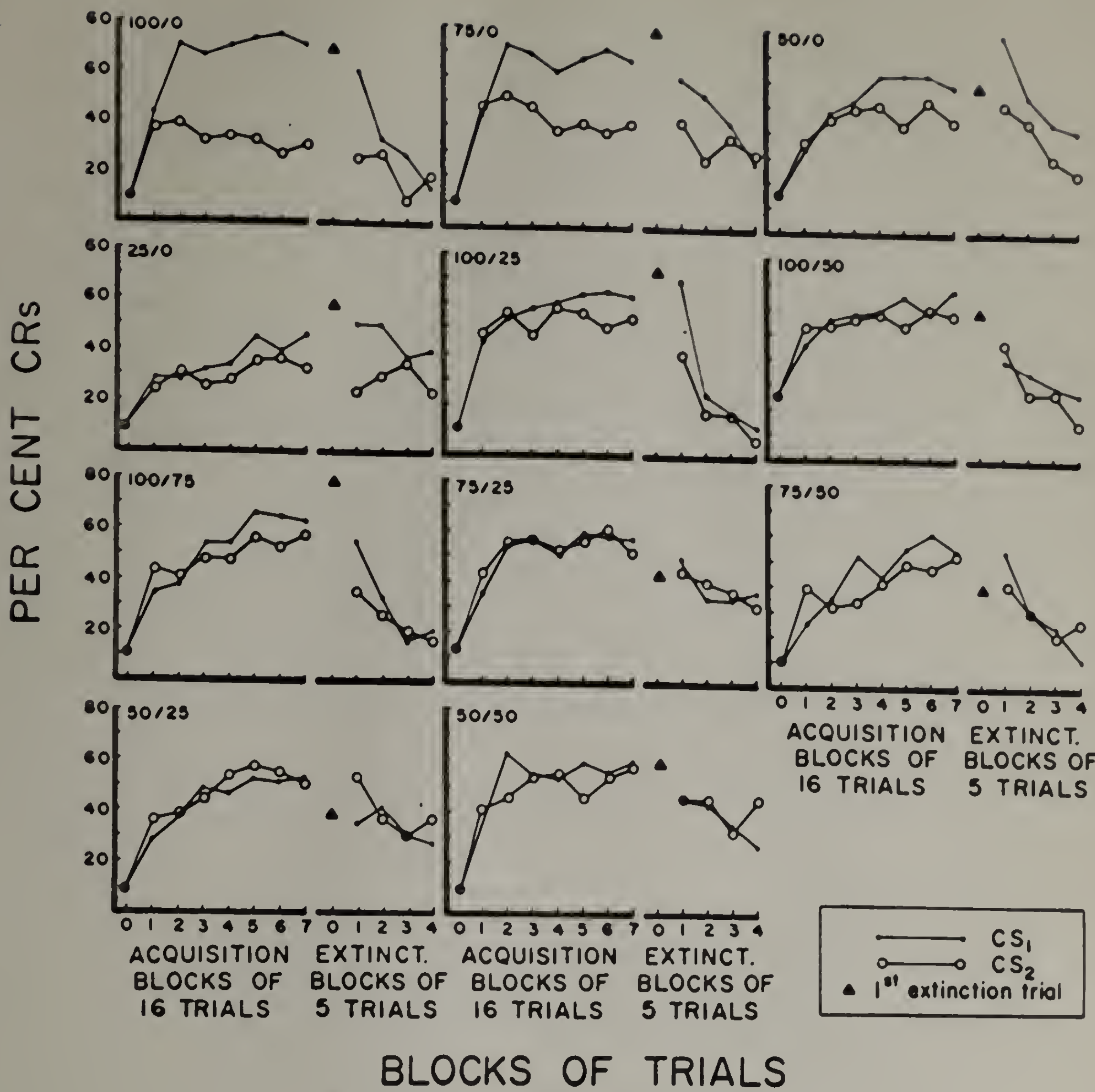

Fig. 1. Per cent CRs to CS_1 and CS_2 for each group over seven blocks of 16 acquisition trials, the first extinction trial, and four blocks of 5 extinction trials.

Table 2

Per Cent CRs to CS_1, CS_2, Difference Scores, and Average Per Cent CRs at Asymptote (Trials 49-112) for Each Group.

Group	% CR_1	% CR_2	Difference	Average
100/0	71.9	30.8	41.1	51.4
75/0	67.7	39.9	27.8	53.8
50/0	62.0	48.2	13.8	55.1
25/0	41.3	32.9	8.4	37.1
100/25	63.3	55.5	7.8	59.4
100/50	63.5	58.0	5.5	60.8
100/75	62.2	54.7	8.5	58.0
75/25	56.6	54.3	1.9	55.7
75/50	53.6	47.8	5.8	50.7
50/25	50.9	53.7	- 3.0	52.3
50/50	57.5	52.9	4.6	55.2

Table 3

F Values Testing the Significance of Differentiation ($Groups \times CS_1 \div \underline{S}s \times CS_1/Groups$, df = 1, 32) Where Each of the Ten Experimental Groups was Contrasted with the Control Group 50/50[a]

Group	*F*
100/0	22.558[b]
75/0	13.146[c]
50/0	4.097
25/0	.078
100/25	.606
100/50	.775
100/75	.627
75/25	.001
75/50	.253
50/25	3.021

[a] The *F* values for the ten complete ANOVAs are presented in Appendix B.

[b] $p < .001$

[c] $p < .01$

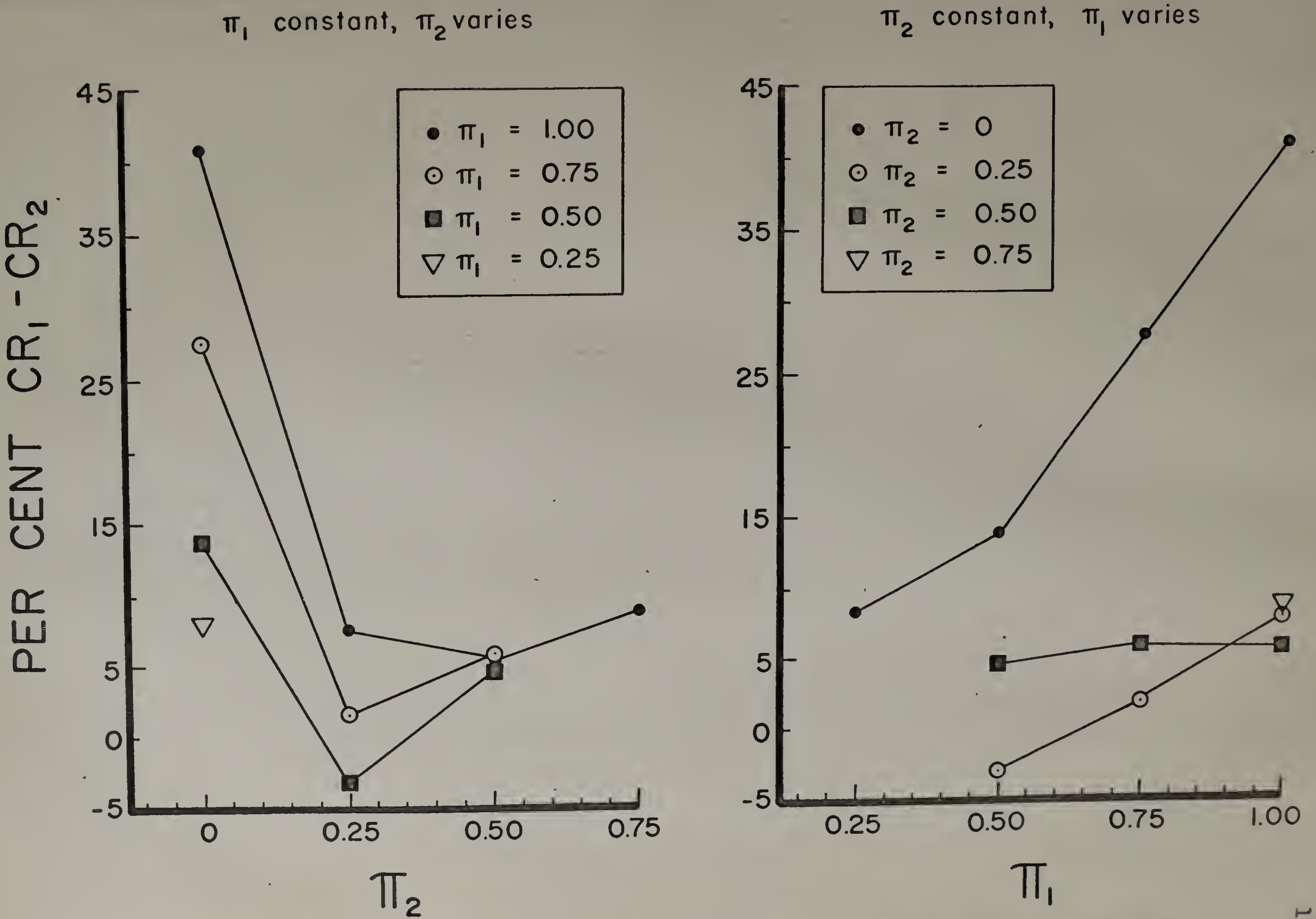

Fig. 2. Per cent difference between CR_1 and CR_2 where a) π_1 is constant and π_2 varies between groups and b) π_2 is constant and π_1 varies.

as the parameter (the right-hand panel). When the parameter is π_1, differentiation appears to have been a decreasing concave upward function of π_2. The linear and quadratic components of these trends were significant in each of the following three analyses of variance of the Groups x CS_1 interactions, as summarized in Section B of Table 4:

(a) 50/0 vs. 50/25 vs. 50/50,

(b) 75/0 vs. 75/25 vs. 75/50, and

(c) 100/0 vs. 100/25 vs. 100/50 vs. 100/75.

The figure shows that the major contributors to both components of trends in the three analyses were Groups 50/0, 75/0, and 100/0. In fact, all significant differences and trends shown in Table 4 resulted almost exclusively from the differential responding exhibited by these three groups.

The right-hand panel of Fig. 2 shows the steep linear trend when $\pi_2 = 0$, $\underline{F}(1, 64) = 21.175$, $\underline{p} < .001$, a slight but significant linear trend when $\pi_2 = .25$, $\underline{F}(1, 48) = 5.347$, $\underline{p} < .05$, and no linear trend when $\pi_2 = .50$. The latter trend was most likely not of the same character as $\pi_2 = 0$, since it probably resulted from the small <u>negative</u> difference score in Group 50/25, where per cent $CR_1 = 50.9$ and $CR_2 = 53.7$.

Taken together, these results indicate that the extent of differentiation in this experiment cannot be considered simply as a function of $\delta\pi$ as suggested by the linear and pattern models. More specifically, when π_1 was less than .50 and π_2 was greater than zero, there was no convincing

Table 4

F Values of Trend Tests on Analyses Comparing Asymptotic Per Cent CR_1

Among Groups for Which Either π_1 or π_2 Was Constant

	A. π_2 Constant		
Source of Variance	$\pi_2 = 0$	$\pi_2 = .25$	$\pi_2 = .50$
	25/0-50/0-75/0-100/0	50/25-75/25-100/25	50/50-75/50-100/50
Groups	1.927 (3, 64)[a]	.175 (2, 48)	.402 (2, 48)
linear	2.534	b	b
quadratic	.515	b	b
cubic	2.732	---	---
Groups x CS_1	7.150[f]	2.889	.394
lin Grps x CS_1	21.175[f]	5.347[c]	b
quad Grps x CS_1	b	b	b

[a] Degrees of freedom for main and crossed effects in that ANOVA.
[b] These terms were not computed since sums square were less than error mean square (cf. Appendix F).
[c] $p < .05$ [d] $p < .025$ [e] $p < .01$ [f] $p < .001$

(Table continued on next page).

Table 4 (continued)

$\underline{F}$ Values of Trend Tests on Analyses Comparing Asymptotic Per Cent CR_1

Among Groups for Which Either π_1 or π_2 Was Constant

	B. π_1 Constant		
Source of Variance	$\pi_1 = .50$	$\pi_1 = .75$	$\pi_1 = 1.00$
	50/0-50/25-50/50	75/0-75/25-75/50	100/0-100/25-100/50-100/75
Groups	.142 (2, 48)[a]	.210 (2, 48)	.236 (3, 64)
linear	b	b	b
quadratic	b	b	b
cubic	---	---	b
Groups x CS_1	6.532[e]	10.125[f]	11.882[f]
lin Grps x CS_1	5.239[c]	6.494[d]	20.930[f]
quad Grps x CS_1	7.824[e]	13.756[f]	10.340[f]

[a] Degrees of freedom for main and crossed effects in that ANOVA.

[b] These terms were not computed since sums square were less than error mean square (cf. Appendix F).

[c] $\underline{p} < .05$ [d] $\underline{p} < .025$ [e] $\underline{p} < .01$ [f] $\underline{p} < .001$

evidence that <u>S</u>s responded differentially at all. Furthermore, the results strongly suggest that while consistent nonreinforcement ($\pi_2 = 0$) may serve as a reliable cue for differentiation, consistent reinforcement ($\pi_1 = 1.00$) does not necessarily operate in the same way. Thus, the statistical contrasts which specifically tested for such an effect were not supported (cf. equations 3 and 4 on page 5 of the introduction). These contrasts are shown in detail in Appendix G.

The two quantitative models predict that CRs to each CS would be directly related to π_1. While per cent CR_2 did show the expected increase as a function of π_1 and π_2, the decreasing concaved CR_1 functions with increasing π_2 were contrary to predictions of the two models (Fig. 3). In this respect, the present results are similar to those found in instrumental probability learning studies (Popper & Atkinson, 1958; Atkinson, Bogartz, & Turner, 1959).

The Hullian version of S-R reinforcement theory also fails to handle these data. Hull-Spence theory says that the response strength to each CS can be expressed in terms of excitation (E), inhibition (I), and stimulus generalization. Specifically, the theory (Gynther, 1957) states that E and I grow as a function of the number of reinforced and nonreinforced trials, respectively, and that a given reinforcement produces an increment in E which is greater than the increment in I produced by nonreinforcement. These notions failed when applied to the present results and this failure was particularly

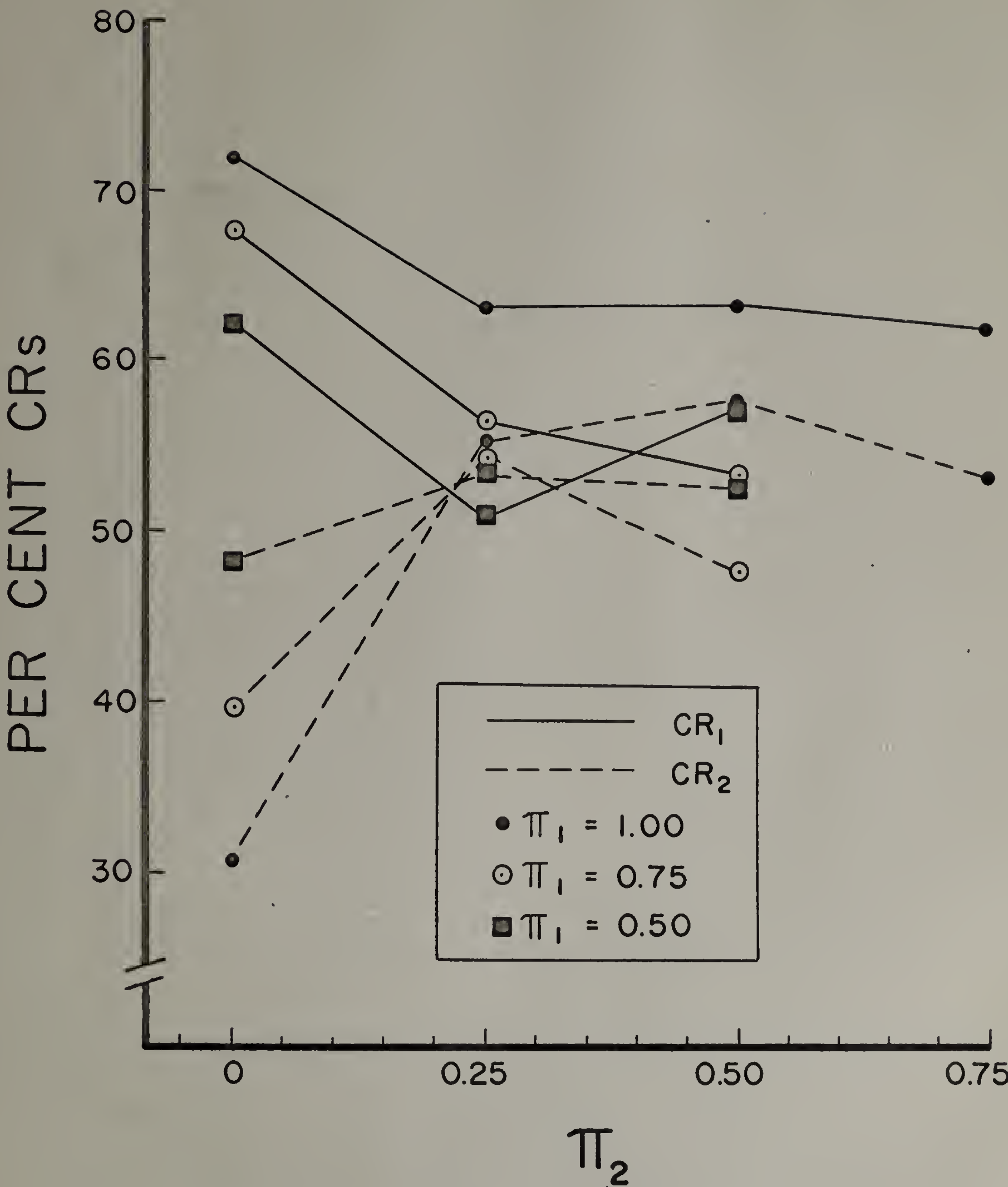

Fig. 3. The percentage CR_1 and CR_2 where π_1 is the parameter and π_2 varies.

evident in one analysis: 100/0 vs. 100/25 vs. 100/50 vs. 100/75. For this analysis, percentage CR_1 was a decreasing function of π_2 rather than the predicted increasing function (Fig. 3) which would have resulted if excitation generalized from CR_2.

The hypothesis that Ss maximize CRs to a potentially reinforced CS in order to attenuate the noxiousness of the UCS received partial support but cannot be utilized as an explanation on the basis of the same results that discredited the simple reinforcement theories. As predicted by a maximization hypothesis, when π_2 was greater than zero, asymptotic per cent CR_1 and CR_2 were not significantly different, but per cent CR_1 was a decreasing function of π_2 (Fig. 3). instead of remaining constant (or maximal). Thus, despite the fact that response latency might have increased (Prokasy, 1965) or that CR efficiency in attenuating the UCS over conditioning trials might have increased (Martin & Levey, 1965), the frequency of a CR was not optimal for attenuation of the noxious effects of the UCS.

Extinction.--The extinction curves for each group are presented in Fig. 1. The left side of Table 5 presents the percentage of CRs in extinction for each group to CS_1, CS_2, difference scores, and the average per cent CRs. The right side of Table 5 presents a mean "extinction index" for CRs to CS_1 (EI_1), CS_2 (EI_2), difference scores ($EI_1 - EI_2$), and average $(EI_1 + EI_2)/2$. The extinction index was originally

Table 5

Per Cent CRs and Extinction Index Scores to CS_1, CS_2,

Difference Scores, and Average for All Groups

	Percentages				Extinction Index			
Group	CS_1	CS_2	Difference	Average	CS_1	CS_2	Difference	Average
100/0	35.0	21.0	14.0	28.0	4.20	3.59	.61	3.90
75/0	51.5	35.0	16.5	43.2	4.36	4.35	.01	4.36
50/0	52.5	38.0	14.5	45.0	4.57	4.54	.03	4.56
25/0	44.5	26.5	18.0	35.5	4.78	4.46	.32	4.62
100/25	30.0	21.0	9.0	25.5	4.05	3.61	.44	3.83
100/50	35.5	30.0	5.5	32.5	4.21	4.27	-.06	4.24
100/75	32.0	23.0	9.0	27.5	4.34	4.28	.06	4.31
75/25	37.0	38.0	-1.0	37.5	4.06	4.55	-.49	4.30
75/50	29.0	30.0	-1.0	29.5	4.18	4.17	.17	4.18
50/25	34.0	40.0	-6.0	37.0	4.34	4.68	-.34	4.50
50/50	39.5	42.5	-3.0	41.0	4.15	4.24	.09	4.20

suggested by Anderson (1963) and more recently employed by Spence, Homzie, and Rutledge (1964) in order to obtain a measure of extinction which takes into account the final acquisition level and which actually gives an estimate of extinction rate. The index as used by Spence et al. (1964) is as follows:

$$EI = (Rext. - \Sigma R_{i,n}/N)/(Rext. - Racq.),$$

where Rext. is the asymptotic extinction level (assumed to be 10 per cent for all Ss in all groups, cf. Spence et al., 1964, p. 548), Racq. is the final acquisition level for each S (per cent CRs to CS_i on the last 16 acquisition trials), and $\Sigma R_{i,n}$ is the number of CRs to CS_i over N extinction trials. The higher the index, the greater the resistance to extinction.

While the percentage of CRs in extinction to both CSs was an inverted-U shaped function of the average percentage of reinforcement, in agreement with other investigators in simple eyelid conditioning studies (Ross & Hartman, 1965), the present results were analyzed in terms of the extinction index. Table 6 showed that there was a tendency for increased resistance to extinction as $(\pi_1 + \pi_2)/2$ decreased where $\pi_2 = 0$ and $\pi_2 = .25$, thus indicating a conventional PRE. The linear trend of the Groups main effect was significant in the analyses of Groups 25/0--50/0--75/0--100/0, $F(1, 64) = 5.84$, $p < .025$ and 50/25--75/25--100/25, $F(1, 48) = 5.35$, $p < .05$. In addition, the latter analysis revealed significant differences between the linear trends of EI_1 and EI_2 among

Table 6

F Values of Trend Tests for Analyses Contrasting the Extinction Index for CS_1 and CS_2 Among Groups

	A. π_1 Constant		
Source of Variance	$\pi_1 = .50$	$\pi_1 = .75$	$\pi_1 = 1.00$
	50/0-50/25-50/50	75/0-75/25-75/50	100/0-100/25-100/50-100/75
Groups	1.036 (2, 48)[a]	.975 (2, 48)	1.079 (3, 64)
linear	1.758	b	2.385
quadratic	b	b	b
cubic	---	---	b
Groups x CS_1	.784	.746	1.393
lin Grps x CS_1	b	b	1.918
quad Grps x CS_1	b	b	b
cubic Grps x CS_1	---	---	b

[a] Degrees of freedom for main and crossed effects in that ANOVA.
[b] These terms were not computed since sums square were less than error mean square (cf. Appendix M).

(Table continued on next page).

Table 6 (continued)

F Values of Trend Tests for Analyses Contrasting the Extinction Index for CS_1 and CS_2 Among Groups

Source of Variance	B. π_2 Constant		
	$\pi_2 = 0$	$\pi_2 = .25$	$\pi_2 = .50$
	25/0-50/0-75/0-100/0	50/25-75/25-100/25	50/50-75/50-100/50
Groups	2.812 (2, 48)[a]	.020 (2, 48)	1.961 (3, 64)
linear	5.347[c]	b	5.840[d]
quadratic	b	b	b
cubic	---	---	b
Groups x CS_1	3.800[c]	.062	.545
lin Grps x CS_1	4.615[c]	b	.135
quad Grps x CS_1	2.965	b	b
cubic Grps x CS_1	---	---	b

[a] Degrees of freedom for main and crossed effects in that ANOVA.

[b] These terms were not computed since sums square were less than error mean square (cf. Appendix M).

[c] $p < .05$ [d] $p < .025$

groups, such that as π_1 increased, resistance to extinction decreased, with EI_2 decreasing at a faster rate than EI_1. These results are shown in Fig. 4. An opposite tendency, i.e., an increase in EI with an increase in $(\pi_1 + \pi_2)/2$, resulted for Groups 100/0--100/25--100/50--100/75. Even though this trend was not significant, such a tendency is not predicted by the PRE literature (Lewis, 1960). These results are shown in Fig. 5.

Table 7 presents the _F_ values for EIs when each of the ten experimental groups is contrasted with the 50/50 control group, and Table 6 shows the _F_ values of analyses and trend tests of mean EI as a function of π_1 and π_2. The statement which would best describe all of the extinction data is that a PRE was obtained only with decreasing π_1 and where π_2 is small (π_2 = 0 or .25 but not .50).

The discrimination hypothesis (Spence, Homzie, & Rutledge, 1964) could be extended to the present study by assuming that if _S_s do differentiate CS_1 from CS_2 in acquisition and respond accordingly, i.e., $CR_1 > CR_2$, then _discriminating the occasion of the extinction trials_ would be facilitated resulting in a more rapid rate of extinction for this group than for a 50/50 group where no differentiation in acquisition is possible. For example, since the 100/0 group in the present experiment did respond differentially to CS_1 and CS_2, these _S_s should have more easily "discriminated" the onset of extinction, and therefore extinguish at a faster rate than

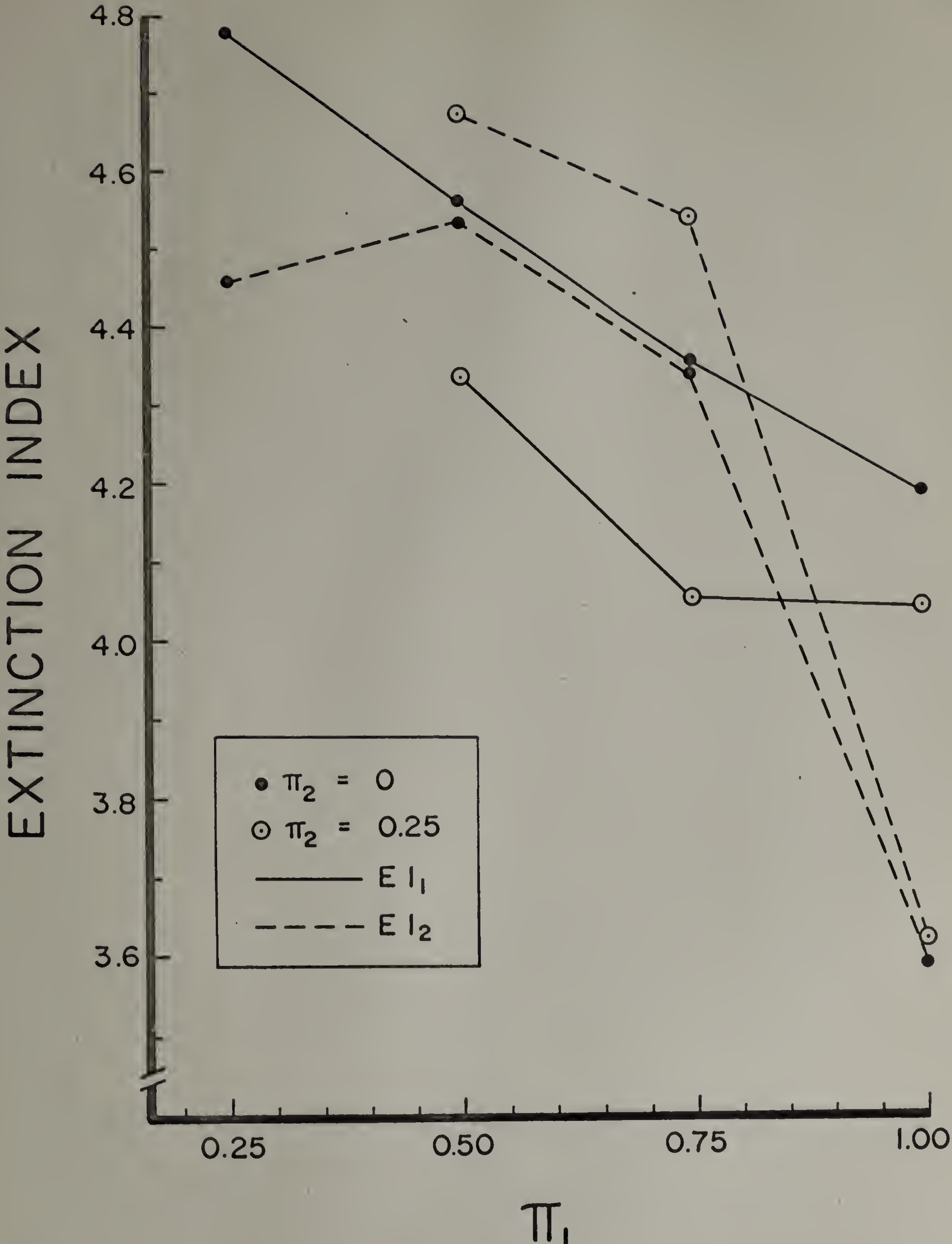

Fig. 4. The extinction index values for resistance to extinction to CS_1 and CS_2 where π_1 varies and $\pi_2 = 0, .25$.

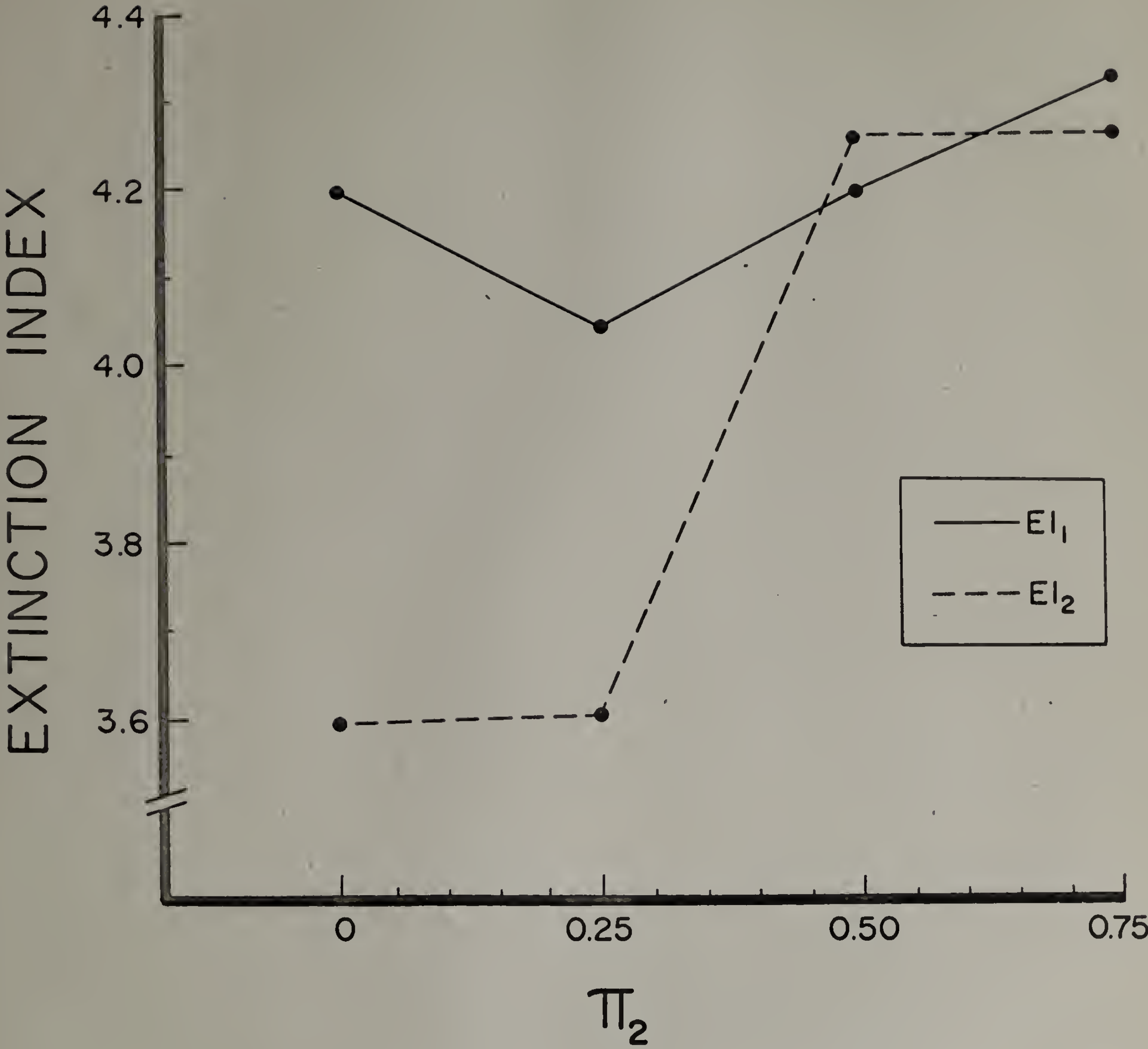

Fig. 5. The EI_1 and EI_2 values for Groups 100/0, 100/25, 100/50, and 100/75.

Table 7

F Values for EIs When Each of the Ten Experimental Groups was Contrasted with the Control Group 50/50 (df = 1,32)[a]

Group Contrasted with Group 50/50	Groups	CS_1 vs. CS_2	Interaction
100/0	..900	.972	1.816
75/0	.343	.031	.043
50/0	1.322	.039	.136
25/0	1.901	.181	.593
100/25	1.136	.857	2.036
100/50	.020	.271	.012
100/75	.305	.012	.200
75/25	.161	1.730	.796
75/50	.003	.041	.082
50/25	1.945	1.769	.566

[a] The F values for the ten complete ANOVAs are presented in Appendix I.

the 50/50 group. It should also be noted that the average percentage of reinforcement for these two groups was equal (i.e., .50), thereby presumably equating drive level. One explicit prediction from this hypothesis is that EI_1 would be smaller for the 100/0 group than EI_1 or EI_2 for the 50/50 group. However, the F values for the 100/0 vs. 50/50 group were not significant (cf. Tables 6 and 7). While it would be unwise to accept a null hypothesis to discredit a discrimination hypothesis, the results showed no evidence for its support.

Another question of interest was whether PREs could be obtained as within-Ss effects in differential eyelid conditioning, similar to those recently demonstrated by Amsel and Ward (1965) and Pavlik, Carlton, and Manto (1965) in appetitive reinforcement situations with rats. The present data suggest a negative answer. For example, if responding in extinction appropriate to continuous reinforcement and partial reinforcement can exist simultaneously for an organism in a single classical conditioning situation, then there should have been significant differences between EI_1 and EI_2 for a within-Ss comparison of Groups 100/25, 100/50, and 100/75. The difference between EI_1 and EI_2 was +.44 for the 100/25 group which contradicts a within-Ss PRE. The 100/50 and the 100/75 groups showed negligible differences of -.06 and +.06, respectively.

Concluding Remarks: Theory.--When partial reinforcement of CS_2 was introduced into the paradigm of differential eyelid conditioning with human Ss, responding to CS_1 did depend upon π_2 as well as π_1, but not as a simple function of generalized excitation and inhibition as described by reinforcement theory. Increasing π_2 above zero resulted in a decrease in per cent CR_1 instead of the predicted increase (Fig. 3).

Since little or no differentiation was exhibited in acquisition or extinction by the groups for which $\pi_2 > 0$, we might assume that Ss in these groups responded as if they were partially reinforced to a single CS on a $(\pi_1 + \pi_2)/2$ reinforcement schedule. Against the notion is the lack of significance of percentage CRs in acquisition as a function of average per cent reinforcement for groups where $\pi_2 > 0$ (cf. Table 2). Furthermore, while an overall PRE in terms of the extinction index was exhibited in groups for which $\pi_2 = 0$ and .25, the opposite trend was obtained in groups for which $\pi_1 = 1.00$.

The data for groups where $\pi_2 = 0$ were clear enough to allow a more complicated theoretical description. The data from the 25/0, 50/0, 75/0, and 100/0 groups are reviewed in Fig. 6 with the values of π_1 along the abscissa and per cent CR_1 and CR_2 plotted separately. Note that CR_1 percentages rose in an negatively accelerated fashion while the CR_2 percentages at first increased with CR_1 and then showed a linear decrease such that the difference between CR_1 and CR_2

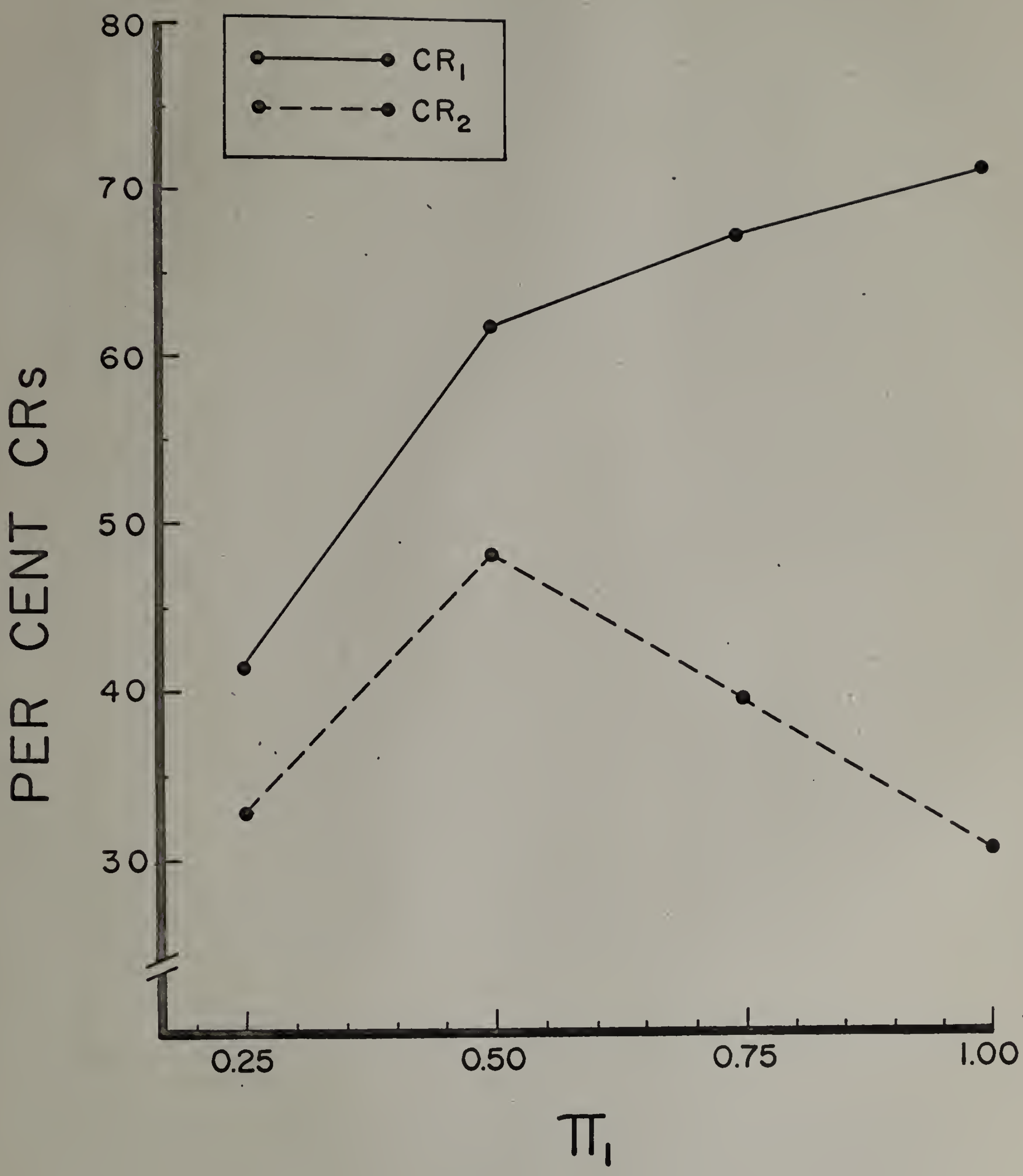

Fig. 6. The mean percentage of CRs to CS_1 (CR_1) and CS_2 (CR_2) as a function of π_1 where $\pi_2 = 0$.

reached significance at $\pi_1 = .75$. This pattern bears a striking similarity to typical acquisition functions for differentiation (cf. Fig. 1, Group 100/0). There is a standard explanation for the differential acquisition data (Kimble, 1961): During those first several trial blocks where there is an increase in both CR_1 and CR_2, <u>S</u>s acquire the potential to respond to CS_1 which in turn generalizes to CS_2. Since responding to CS_2 is not reinforced, extinction of CRs to CS_2 results, and as a consequence CS_2 eventually becomes inhibitory. However, since the results shown in Fig. 6 represent asymptotic data, i.e., where E and I effects have had ample opportunity to play their respective roles, this interpretation may not apply.

Recall that significant differentiation was obtained if, and only if, the UCS was paired with only one CS (CS_1) and the $P(UCS \mid CS_1) > .50$. This finding only specifies the limits of π_1 and π_2 <u>necessary</u> to obtain differential eyelid conditioning in humans but does not specify the underlying psychological mechanism that brings about differential responding. The type of explanation we propose is that response-produced cues (S_{rc}) derived from a recognition of the CS-UCS contingency become part of a CS complex. Where $\pi_2 = 0$, the result of adding S_{rc} to the CS_1 complex and not to the CS_2 complex is to emphasize the distinctiveness between CS_1 and CS_2, thereby making differentiation possible. When both CS_1 and CS_2 are reinforced, however, S_{rc} becomes associated with both CS complexes and thereby hinders differentiation.

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Appendix A

Neutral Instructions

Please listen carefully to the following instructions. Remain seated comfortably and keep looking directly in front of you. Do not touch anything on your head at any time. You will hear and feel a series of stimuli during the experimental session. Do not try to control voluntarily your natural reaction to the stimuli, but rather let your reactions take care of themselves. Do not try to figure out the nature of the experiment, but keep as detached an attitude as possible. You will be able to communicate with me at any time by speaking in a normal voice. (If there are two Ss, then "But please do not communicate with each other.") Are these instructions clear?

Appendix B

Acquisition: Resulting $\underline{F}$ Values and Degrees of Freedom of all Main and Crossed Effects, and the Error Mean Square (in parentheses) for Each Analysis of Variance[a] Contrasting Each Experimental Group with the 50/50 Control Group

Source of Variance	df	100/0	75/0	50/0
A (Groups)	1	..393	.199	.027
B (Direction)	1	3.016	5.051[b]	3.592
C (Channel-Sex)	1	4.451[b]	2.579	5.422[b]
AB	1	1.652	.164	.481
AC	1	1.568	1.810	.304
BC	1	1.990	1.127	.128
ABC	1	.102	.209	3.387
S/ABC	32	(63,070.69)	(81,843.94)	(85,957.06)
D (CS_1 vs. CS_2)	1	34.083[e]	24.323[e]	13.332[e]
AD	1	22.558[e]	13.146[d]	4.097
BD	1	1.517	.236	2.223
CD	1	2.064	1.626	1.148
ABD	1	1.967	.477	3.049
ACD	1	.591	4.311[b]	.005
BCD	1	1.001	.566	.000
ABCD	1	.869	.449	.005
SD/ABC	32	(13,903.08)	(9,657.63)	(6,221.86)

[a] The analyses were performed on the arc sine transforms times 100 of the per cent CRs on trials 49-112.

[b] $\underline{p} < .05$ [c] $\underline{p} < .025$ [d] $\underline{p} < .01$ [e] $\underline{p} < .001$

(Table continued on next page).

Appendix B (continued)

Source of Variance	df	25/0	100/25	100/50
A (Groups)	1	5.001[b]	.009	.055
B (Direction)	1	.234	2.986	1.889
C (Channel-Sex)	1	2.790	4.564[b]	6.917[c]
AB	1	4.300[b]	.519	1.099
AC	1	1.381	.345	.004
BC	1	.380	2.033	.519
ABC	1	.719	.000	.444
S/ABC	32	(88,039.64)	(96,080.73)	(98,135.71)
D (CS_1 vs. CS_2)	1	3.117	7.202[c]	8.830[d]
AD	1	.077	.606	.775
BD	1	.262	.003	.787
CD	1	3.209	5.042[b]	.190
ABD	1	.555	.127	.313
ACD	1	7.307[c]	1.160	2.952
BCD	1	.080	1.175	.034
ABCD	1	.036	.930	.003
SD/ABC	32	(7,450.86)	(4,537.97)	(3,765.88)

[b] $p < .05$

[c] $p < .025$

[d] $p < .01$

(Table continued on next page).

Appendix B (continued)

Source of Variance	df	100/75	75/25
A (Groups)	1	.008	.001
B (Direction)	1	.278	2.618
C (Channel-Sex)	1	6.094[c]	7.272[c]
AB	1	4.909[b]	.399
AC	1	.340	.037
BC	1	1.286	.016
ABC	1	.191	1.346
S/ABC	32	(76,540.54)	(113,803.43)
D (CS_1 vs. CS_2)	1	6.111[c]	4.993[b]
AD	1	.627	.000
BD	1	.002	2.149
CD	1	.051	.317
ABD	1	.095	1.254
ACD	1	1.580	.624
BCD	1	.046	.019
ABCD	1	.103	.075
SD/ABC	32	(5,835.19)	(3,385.68)

[b] $p < .05$

[c] $p < .025$

(Table continued on next page).

Appendix B (continued)

Source of Variance	df	75/50	50/25
A (Groups)	1	.425	.255
B (Direction)	1	1.075	1.210
C (Channel-Sex)	1	4.203[b]	2.932
AB	1	1.562	1.395
AC	1	.244	.682
BC	1	.972	.000
ABC	1	.105	1.657
S/ABC	32	(110,133.33)	(110,649.83)
D (CS_1 vs. CS_2)	1	7.223[c]	.237
AD	1	.252	3.021
BD	1	.097	1.984
CD	1	.469	.479
ABD	1	.429	1.001
ACD	1	.429	.452
BCD	1	1.410	.037
ABCD	1	1.103	.110
SD/ABC	32	(3,450.14)	(3,328.61)

[b] $p < .05$

[c] $p < .025$

Appendix C

Acquisition: Resulting F Values and Degrees of Freedom of all Main and Crossed Effects, and the Error Mean Square (in parentheses) for Each Analysis of Variance[a] Contrasting Those Groups for Which π_2 Values were Equal

Source of Variance	df	$\pi_2 = 0$ 25/0 vs. 50/0 vs. 75/0 vs. 100/0	df	$\pi_2 = .25$ 50/25 vs. 75/25 vs. 100/25
A (Groups)	3	1.927	2	.175
B (Direction)	1	.417	1	.470
C (Channel-Sex)	1	1.409	1	3.764
AB	3	1.166	2	.151
AC	3	.237	2	.456
BC	1	.109	1	.127
ABC	3	1.038	2	.860
S/ABC	64	(81,398.02)	48	(135,631.67)
D (CS_1 vs. CS_2)	1	60.141[c]	1	3.409
AD	3	7.150[c]	2	2.889
BD	1	5.098[b]	1	2.663
CD	1	1.100	1	1.784
ABD	3	.335	2	1.174
ACD	3	3.279[b]	2	2.109
BCD	1	1.491	1	.280
ABCD	3	.303	2	1.085
SD/ABC	64	(15,303.37)	48	(4,188.15)

[a] The analyses were performed on the arc sine transforms times 100 of the per cent CRs on trials 49-112.

[b] $p < .05$ [c] $p < .001$

Appendix C (continued)

Source of Variance	df	$\pi_2 = .50$ 50/50 vs. 75/50 vs. 100/50
A (Groups)	2	.402
B (Direction)	1	.923
C (Channel-Sex)	1	6.919[b]
AB	2	.849
AC	2	.141
BC	1	.665
ABC	2	.193
S/ABC	48	(112,826.81)
D (CS_1 vs. CS_2)	1	13.707[c]
AD	2	.395
BD	1	.122
CD	1	.120
ABD	2	.715
ACD	2	1.536
BCD	1	1.067
ABCD	2	.651
SD/ABC	48	(3,706.23)

[b] $p < .05$

[c] $p < .001$

Appendix D

Acquisition: Resulting F Values and Degrees of Freedom of all Main and Crossed Effects, and the Error Mean Square (in parentheses) for Each Analysis of Variance[a] Contrasting Those Groups for Which π_1 Values were Equal

Source of Variance	df	$\pi_1 = .50$ 50/0 vs. 50/25 vs. 50/50	df	$\pi_1 = 1.00$ 75/0 vs. 75/25 vs. 75/50
A (Groups)	2	.142	2	.210
B (Direction)	1	1.864	1	.825
C (Channel-Sex)	1	4.373[b]	1	3.247
AB	2	.735	2	.370
AC	2	.363	2	.860
BC	1	.633	1	.003
ABC	2	1.545	2	.395
S/ABC	48	(105,052.04)	48	(125,796.14)
D (CS_1 vs. CS_2)	1	8.038[d]	1	29.196[e]
AD	2	6.531[d]	2	10.125[e]
BD	1	.311	1	.010
CD	1	.917	1	2.519
ABD	2	3.843[b]	2	1.272
ACD	2	.223	2	2.276
BCD	1	.000	1	1.397
ABCD	2	.063	2	.553
SD/ABC	48	(5,262.53)	48	(7,682.28)

[a] The analyses were performed on the arc sine transforms times 100 of the per cent CRs on trials 49-112.

[b] $p < .05$ [c] $p < .025$ [d] $p < .01$ [e] $p < .001$

Appendix D (continued)

Source of Variance	df	$\pi_1 = 1.00$ 100/0 vs. 100/25 vs. 100/50 vs. 100/75
A (Groups)	3	.236
B (Direction)	1	.005
C (Channel-Sex)	1	5.743[c]
AB	3	.634
AC	3	.326
BC	1	1.224
ABC	3	.181
S/ABC	64	(88,856.19)
D (CS_1 vs. CS_2)	1	45.181[e]
AD	3	11.882[e]
BD	1	.895
CD	1	.663
ABD	3	1.349
ACD	3	2.083
BCD	1	1.345
ABCD	3	.685
SD/ABC	64	(10,707.71)

[c] $p < .025$

[e] $p < .001$

Appendix E

Acquisition: The Source of Variance Table for the Analysis of Variance[a] Contrasting All Eleven Groups

Source of Variance	df	MS	F
A (Groups)	10	85,077.59	.817
B (Direction)	1	97,267.64	.934
C (Channel-Sex)	1	1,322,433.83	12.694[b]
AB	10	73,071.71	.701
AC	10	43,289.90	.415
BC	1	3,483.28	.033
ABC	10	64,684.87	.621
S/ABC	176	104,180.99	
D (CS_1 vs. CS_2)	1	658,983.60	77.732[b]
AD	10	71,293.71	8.410[b]
BD	1	11,649.31	1.374
CD	1	4,660.51	.550
ABD	10	10,885.82	1.284
ACD	10	20,612.81	2.431
BCD	1	17,716.51	2.090
ABCD	10	3,889.97	.459
SD/ABC	176	8,477.60	

[a] The analyses were performed on the arc sine transforms times 100 of the per cent CRs on trials 49-112.

[b] $p < .001$

Appendix F

Acquisition: The Sums of Squares for the Main Effects of Groups and the Interaction, Groups x (CS_1 vs. CS_2), along with Mean Square Values for the Between- and Within-Ss Error Terms for the Analyses of Variance upon which Trend Tests Were Performed (cf. Table 4).

A. π_1 Constant

Source of Variance	df	$\pi_1 = .50$ 50/0-50/25-50/50	df	$\pi_1 = .75$ 75/0-75/25-75/50	df	$\pi_1 = 1.00$ 100/0-100/25-100/50-100/75
Groups (SS)	2	29,874.52	2	52,824.05	3	62,855.30
S/ABC (MS)	48	105,052.04	48	125,796.14	64	88,856.19
Grps x CS_1 (SS)	2	68,745.14	2	155,562.62	3	381,675.27
SD/ABC (MS)	48	5,262.53	48	7,682.28	64	10,707.71

B. π_2 Constant

Source of Variance	df	$\pi_2 = 0$ 25/0-50/0-75/0-100/0	df	$\pi_2 = .25$ 50/25-75/25-100/25	df	$\pi_2 = .50$ 50/50-75/50-100/50
Groups (SS)	3	470,674.52	2	47,440.87	2	90,710.72
S/ABC (MS)	64	81,398.02	48	135,631.67	48	112,826.81
Grps x CS_1 (SS)	3	328,274.47	2	24,198.46	2	2,924.55
SD/ABC (MS)	64	15,303.37	48	4,188.15	48	3,706.23

Appendix G

Acquisition: Contrasts of CR_1 vs. CR_2 Between Groups Testing *a priori* Predictions by Partitioning the Groups x CS_1 Sums of Squares from the Analysis of Variance Performed on All Eleven Groups

A. Quantitative models' predictions based upon $\delta\pi$.

100/0 > (100/25 = 75/0) > (100/50 = 75/25 = 50/0) > (100/75 = 75/50 = 50/25 = 25/0) > 50/50

1. 100/0 > (100/25 = 75/0)

   SS = 168,646.0167 $\quad$ $F = 19.8930$ $\quad$ $p < .001$

2. (100/25 = 75/0) > (100/50 = 75/25 = 50/0)

   SS = 42,197.8800 $\quad$ $F = 4.9776$ $\quad$ $p < .05$

3. (100/50 = 75/25 = 50/0) > (100/75 = 75/50 = 50/25 = 25/0)

   SS = 16,012.5670 $\quad$ $F < 1$ $\quad$ N.S.

4. (100/75 = 75/50 = 50/25 = 25/0) > 50/50

   SS = 31.5188 $\quad$ $F < 1$ $\quad$ N.S.

B. Cue value of reinforcement, equation 3 from introduction.

100/0 > (75/0 = 50/0 = 25/0 = 100/25 = 100/50 = 100/75) > (75/25 = 75/50 = 50/25 = 50/50)

1. 100/0 > (75/0 = 50/0 = 25/0 = 100/25 = 100/50 = 100/75)

   SS = 335,214.50 $\quad$ $F = 39.5412$ $\quad$ $p < .001$

2. (75/0 = 50/0 = 25/0 = 100/25 = 100/50 = 100/75) > (75/25 = 75/50 = 50/25 = 50/50)

   SS = 87,604.17 $\quad$ $F = 10.3335$ $\quad$ $p < .01$

3. (75/0 = 50/0 = 25/0) = (100/25 = 100/50 = 100/75)

   SS = 46,398.20 $\quad$ $F = 5.473$ $\quad$ $p < .025$

4. (100/25 = 100/50 = 100/75) > (75/25 = 75/50 = 50/25 = 50/50)

   SS = 18,228.06 $\quad$ $F = 2.150$ $\quad$ N.S.

Appendix G (continued)

C. Cue value of reinforcement and differentiation as a function of $\delta\pi$ combined, equation 4 from the introduction.

100/0 > (75/0 = 100/25) > (50/0 = 100/50) > (25/0 = 100/75) > (75/25 = 75/50 = 50/25) > 50/50

1. 100/0 > (75/0 = 100/25)

   SS = 168,646.0167 F = 19.893 $p < .001$

2. (75/0 = 100/25) > (50/0 = 100/50)

   SS = 19,031.4062 F = 2.245 N.S.

3. (50/0 = 100/50) > (25/0 = 100/75)

   SS = 8,337.6562 F = .983 N.S.

4. (25/0 = 100/75) > (75/25 = 75/50 = 50/25)

   SS = 10,231.6800 F = 1.207 N.S.

5. (75/25 = 75/50 = 50/25) > 50/50

   SS = 795.675 F = .094 N.S.

Appendix H

The Observed First-Order Conditional Probabilities, the Frequency (Denominator) Contributing to Each Conditional,[a] and the Marginal Probabilities for Each Group

Conditional	100/0		75/0		50/0	
	Observed	Freq.	Observed	Freq.	Observed	Freq.
$P_{1,1111}$	.808	125	.841	107	.760	75
$P_{1,2111}$	.363	322	.537	201	.622	111
$P_{1,1112}$	---	---	.600	15	.811	37
$P_{1,2112}$	---	---	.398	98	.693	166
$P_{1,1121}$	.491	55	.472	53	.400	45
$P_{1,2121}$	.297	118	.212	99	.246	69
$P_{1,1122}$	---	---	.000	5	.305	23
$P_{1,2122}$	---	---	.167	42	.149	94
$P_{1,1211}$	---	---	---	---	---	---
$P_{1,2211}$	---	---	---	---	---	---
$P_{1,1212}$	.759	143	.851	188	.809	230
$P_{1,2212}$	.333	66	.667	69	.725	80
$P_{1,1221}$	---	---	---	---	---	---
$P_{1,2221}$	---	---	---	---	---	---
$P_{1,1222}$	.703	327	.544	372	.439	230
$P_{1,2222}$	.167	104	.270	111	.280	100
<u>Marginal</u>						
P_{11}	.719		.677		.620	
P_{12}	.308		.399		.482	

[a] For notational convenience let $P(CR_n \mid CS_{i,n} CS_{j,n-1} A_{k,n-1} E_{m,n-1}) = P_{1,ijkm}$ where A_1 = CR, A_2 = No CR, E_1 = UCS, E_2 = No UCS and where $i,j,k,m = 1,2$.

Appendix H (continued)

Conditional	25/0		100/25		100/50	
	Observed	Freq.	Observed	Freq.	Observed	Freq.
$P_{1,1111}$	.714	7	.820	111	.836	110
$P_{1,2111}$	.500	46	.710	283	.778	284
$P_{1,1112}$	.677	65	---	---	---	---
$P_{1,2112}$	.478	136	---	---	---	---
$P_{1,1121}$	.308	13	.391	69	.414	70
$P_{1,2121}$	.351	74	.255	147	.231	156
$P_{1,1122}$	.284	95	---	---	---	---
$P_{1,2122}$	.207	184	---	---	---	---
$P_{1,1211}$	---	---	.871	62	.867	150
$P_{1,2211}$	---	---	.957	23	.795	39
$P_{1,1212}$	.634	153	.780	200	.776	116
$P_{1,2212}$	.586	58	.699	73	.687	67
$P_{1,1221}$	---	---	.397	58	.364	110
$P_{1,2221}$	---	---	.471	17	.333	21
$P_{1,1222}$	.283	307	.379	140	.298	84
$P_{1,2222}$	.156	122	.313	66	.340	53
<u>Marginal</u>						
P_{11}	.413		.633		.635	
P_{12}	.329		.555		.580	

Appendix H (continued)

Conditional	100/75		75/25		75/50	
	Observed	Freq.	Observed	Freq.	Observed	Freq.
$P_{1,1111}$	.819	105	.854	89	.809	89
$P_{1,2111}$	.689	283	.762	168	.753	158
$P_{1,1112}$	---	---	.700	10	.545	11
$P_{1,2112}$	---	---	.793	82	.526	76
$P_{1,1121}$	.453	75	.282	71	.296	71
$P_{1,2121}$	.376	157	.273	132	.268	142
$P_{1,1122}$	---	---	.200	10	.111	9
$P_{1,2122}$	---	---	.155	58	.125	64
$P_{1,1211}$	.775	209	.797	64	.811	123
$P_{1,2211}$	.732	56	.952	21	.828	29
$P_{1,1212}$	.861	36	.803	188	.724	87
$P_{1,2212}$	.674	46	.733	75	.603	58
$P_{1,1221}$	.380	171	.321	56	.362	138
$P_{1,2221}$	.136	44	.158	19	.452	31
$P_{1,1222}$	.455	44	.230	152	.265	113
$P_{1,2222}$	.176	34	.308	65	.161	62
Marginal						
P_{11}	.622		.566		.536	
P_{12}	.537		.547		.478	

Appendix H (continued)

Conditional	50/25		50/50	
	Observed	Freq.	Observed	Freq.
$P_{1,1111}$	.760	50	.786	70
$P_{1,2111}$	.837	104	.784	102
$P_{1,1112}$	.609	46	.675	40
$P_{1,2112}$	.803	117	.691	149
$P_{1,1121}$	.260	50	.380	50
$P_{1,2121}$	.281	94	.385	78
$P_{1,1122}$	.235	34	.250	20
$P_{1,2122}$	.211	113	.243	111
$P_{1,1211}$	.750	60	.797	138
$P_{1,2211}$	.864	22	.711	38
$P_{1,1212}$	.785	191	.745	78
$P_{1,2212}$	.732	71	.708	65
$P_{1,1221}$	.300	60	.434	122
$P_{1,2221}$	.389	18	.318	22
$P_{1,1222}$	.168	149	.275	112
$P_{1,2222}$	.275	69	.127	55
Marginal				
P_{11}	.507		.575	
P_{12}	.537		.529	

Appendix I

Extinction: Resulting F Values and Degrees of Freedom of all Main and Crossed Effects, and Error Mean Square (in parentheses) for Each Analysis of Variance Performed on the EI Scores Contrasting Each Experimental Group with the 50/50 Control Group

Source of Variance	df	Groups Contrasted with Group 50/50			
		100/0	75/0	50/0	25/0
A (Groups)	1	.900	.343	1.323	1.901
B (Direction)	1	.257	3.628	2.029	.346
C (Channel-Sex)	1	3.525	1.648	3.580	3.176
AB	1	.620	.203	.022	3.545
AC	1	.360	2.354	.304	.485
BC	1	.521	.001	.767	1.092
ABC	1	.035	.328	1.967	.261
S/ABC	32	(1.937)	(1.533)	(1.991)	(1.936)
D (CS_1 vs. CS_2)	1	.972	.031	.039	.181
AD	1	1.816	.043	.136	.593
BD	1	1.614	.971	.418	1.464
CD	1	1.158	.000	.661	.218
ABD	1	.015	.248	2.374	.014
ACD	1	.016	1.021	.447	1.879
BCD	1	2.375	.003	.677	.129
ABCD	1	.019	2.399	1.898	.957
SD/ABC	32	(1.351)	(1.194)	(.549)	(1.487)

(Table continued on next page).

Appendix I (continued)

Source of Variance	df	Groups Contrasted with Group 50/50		
		100/25	100/50	100/75
A (Groups)	1	1.136	.020	.305
B (Direction)	1	.313	.006	.639
C (Channel-Sex)	1	.890	1.552	4.350[a]
AB	1	.403	1.306	1.232
AC	1	1.804	1.190	2.467
BC	1	2.427	.744	.068
ABC	1	1.135	.013	.277
S/ABC	32	(2.275)	(2.177)	(.889)
D (CS_1 vs. CS_2)	1	.857	.271	.012
AD	1	2.036	.012	.200
BD	1	.036	2.143	.782
CD	1	2.541	1.032	1.775
ABD	1	3.071	.934	1.615
ACD	1	.078	.405	.018
BCD	1	3.869	1.364	1.909
ABCD	1	.000	1.633	.619
SD/ABC	32	(.704)	(.445)	(.566)

[a] $p < .05$

(Table continued on next page).

Appendix I (continued)

Source of Variance	df	Groups Contrasted with Group 50/50		
		75/25	75/50	50/25
A (Groups)	1	.161	.003	1.945
B (Direction)	1	.808	1.007	.286
C (Channel-Sex)	1	6.885[b]	1.144	2.355
AB	1	.307	.112	1.575
AC	1	.013	2.230	3.581
BC	1	.127	.381	1.499
ABC	1	.059	.004	.236
S/ABC	32	(1.535)	(1.811)	(1.013)
D (CS_1 vs. CS_2)	1	1.730	.041	1.768
AD	1	.796	.082	.565
BD	1	1.289	4.111	.061
CD	1	1.620	.018	.501
ABD	1	.247	.021	3.924
ACD	1	.027	2.005	.651
BCD	1	.406	.739	1.553
ABCD	1	1.010	1.072	.991
SD/ABC	32	(.987)	(.741)	(.530)

[b] $p < .025$

Appendix J

Extinction: Resulting *F* Values and Degrees of Freedom of all Main and Crossed Effects, and Error Mean Square (in parentheses) for Each Analysis of Variance Performed on the EI Scores Contrasting Those Groups for which π_2 Values Were Equal

Source of Variance	*df*	$\pi_2 = 0$ 25/0 vs. 50/0 vs. 75/0 vs. 100/0	*df*	$\pi_2 = .25$ 50/25 vs. 75/25 vs. 100/25	*df*	$\pi_2 = .50$ 50/50 vs. 75/50 vs. 100/50
A (Groups)	3	1.960	2	2.812	2	.020
B (Direction)	1	.098	1	.017	1	.099
C (Channel-Sex)	1	1.382	1	.429	1	.747
AB	3	1.910	2	.100	2	.708
AC	3	.234	2	1.232	2	1.051
BC	1	.012	1	3.325	1	.929
ABC	3	1.302	2	1.083	2	.075
S/ABC	64	(2.180)	48	(1.697)	48	(2.152)
D (CS_1 vs. CS_2)	1	1.595	1	.761	1	.125
AD	3	.545	2	3.790[a]	2	.062
BD	1	.545	1	.958	1	4.710[b]
CD	1	.289	1	2.164	1	.000
ABD	3	.302	2	.937	2	.659
ACD	3	.835	2	.628	2	1.481
BCD	1	.080	1	.558	1	.638
ABCD	3	.838	2	.839	2	.982
SD/ABC	64	(1.470)	48	(.659)	48	(.517)

[a] $p < .05$ [b] $p < .025$

Appendix K

Extinction: Resulting F Values and Degrees of Freedom of all Main and Crossed Effects, and Error Mean Square (in parentheses) for Each Analysis of Variance Performed on the EI Scores Contrasting Those Groups for which π_1 Values Were Equal

Source of Variance	df	$\pi_1 = .50$ 50/0 vs. 50/25 vs. 50/50	df	$\pi_1 = .75$ 75/0 vs. 75/25 vs. 75/50	df	$\pi_1 = 1.00$ 100/0 vs. 100/25 vs. 100/50 vs. 100/75
A (Groups)	2	1.036	2	.194	3	1.079
B (Direction)	1	1.209	1	1.730	1	.331
C (Channel-Sex)	1	2.762	1	.471	1	.210
AB	2	.848	2	.504	3	.104
AC	2	1.225	2	1.166	3	.230
BC	1	.063	1	.014	1	2.706
ABC	2	2.283	2	.183	3	.714
S/ABC	48	(1.497)	48	(1.734)	64	(2.121)
D (CS_1 vs. CS_2)	1	1.223	1	.644	1	3.818
AD	2	.784	2	.746	3	1.393
BD	1	.035	1	1.363	1	.000
CD	1	.480	1	.152	1	2.989
ABD	2	2.596	2	.246	3	.868
ACD	2	.450	2	.746	3	.246
BCD	1	.735	1	.762	1	2.800
ABCD	2	1.238	2	.336	3	.657
SD/ABC	48	(.446)	48	(1.127)	64	(.712)

Appendix L

Extinction: Resulting F Values and Degrees of Freedom of All Main and Crossed Effects, and the Mean Square of the Error Terms (in parentheses) for Each Analysis of Variance Performed on the EI Scores Contrasting All Eleven Groups.

Source of Variance	df	MS	F
A (Groups)	10	2.465	1.321
B (Direction)	1	.136	.073
C (Channel-Sex)	1	5.102	2.733
AB	10	1.623	.870
AC	10	1.061	.539
BC	1	3.340	1.790
ABC	10	1.687	.904
S/ABC	176	1.866	
D (CS_1 vs. CS_2)	1	.225	.255
AD	10	1.018	1.152
BD	1	.770	.871
CD	1	.182	.206
ABD	10	.639	.723
ACD	10	.812	.919
BCD	1	.256	.289
ABCD	10	.647	.733
SD/ABC	176	.884	

Appendix M

Extinction: The Sums of Squares for the Main Effects of Groups and the Interaction, Groups x (CS_1 vs. CS_2), along with Mean Square Values for the Between- and Within-S Error Terms for the Analyses of Variance upon which Trend Tests Were Performed (cf. Table 6).

A. π_1 Constant

Source of Variance	df	$\pi_1 = .50$ 50/0-50/25-50/50	df	$\pi_1 = .75$ 75/0-75/25-75/50	df	$\pi_1 = 1.00$ 100/0-100/25-100/50-100/75
Groups (SS)	2	3.100	2	.675	3	6.866
S/ABC (MS)	48	1.497	48	1.734	64	2.121
Grps x CS_1 (SS)	2	.699	2	1.681	3	2.976
SD/ABC (MS)	48	.446	48	1.127	64	.712

B. π_2 Constant

Source of Variance	df	$\pi_2 = 0$ 25/0-50/0-75/0-100/0	df	$\pi_2 = .25$ 50/25-75/25-100/25	df	$\pi_2 = .50$ 50/50-75/50-100/50
Groups (SS)	3	12.824	2	9.543	2	.084
S/ABC (MS)	64	2.839	48	1.697	48	2.152
Grps x CS_1 (SS)	3	2.405	2	4.997	2	.064
SD/ABC (MS)	64	1.470	48	.659	48	.517